Production of Biodiesel from Jatropha Curcas by using Heterogenous Dopped Zinc Oxide

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Abstract:
Heterogenous copper based nano catalyst was synthesized by Co-precipitation method. The effect of nano catalyst particle size from 0.5 to 52 nm was investigated. The Cupper dopped zinc oxide the nano particle size was used from 0.5 to 52 nm, and Transesterification method was used to produce the biodiesel. The optimum yield of bio-biodiesel was obtained 92% from Jatropha Curcas seed oil. SEM shows the surface morphology, topography, composition, crystallographic and structural shape of synthesized Cu-ZnO nano catalyst. XRD and EDX results depicted good morphology of prepared catalyst. XRD and EDX also displays the pattern of a model Cu-ZnO. FTIR results showed the major functional groups identified were alkanes, aromatics, and carboxylic acid. Among these functional groups, alkanes were qualitatively noted to be the main constituents which indicate the good catalytic cracking activity of the catalyst. The UV, absorbance peak indicated the presence of ZnO nanoparticles, which is in accordance with UV absorbance result shown by previous studies. The effect of temperature on biodiesel yield showed from higher yield with 45oC from 64.33 to 80 ml of ethanol concentration at 45oC. On further rise in temperature resulted 92% product yield. Furthermore, effect of methanol on bio-diesel yield showed that, as the methanol ratio subsequently increased from 1:05 to 1:12 increased the product yield. Besides this, the heterogeneous nano catalyst showed good catalytic activity in transforming Jatropha seed oil up to 92% of biodiesel yield.

Keywords: Biodiesel, Jatropha, Heterogenous Catalysis.

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Introduction:
In recent years, the depletion of fossil fuel supplies, rising demand and cost of petroleum-based fuels, and environmental dangers associated with their use have prompted researchers to study the
idea of utilizing alternative fuels instead of fossil fuels. Pakistan is also facing fuel crises. The energy requirement in future will rise three times in 2050. The primary source for energy supply is fossil fuels, but the major problem with the planet's atmosphere through burning of these fuels is damage to the ozone layer with emission of gases such as CO, CO2 and NOx (2). The disastrous impacts of these gases on environmental pollution, climate change, and ozone depletion, as well as human health, are well known. Based on a recent US Geological Survey (USGS) review of world oil resources using a basic, transparent model, the US Department of Energy's Energy Information Administration (EIA) has forecast that global oil output might continue to rise for more than three decades. However, it can be demonstrated that this model is incompatible with real oil production data from many various places, notably those from the United States, from where it was formed [3]. Biofuels can be an excellent alternative to fossil fuels that meet all the energy security demands. The major driving factor for the usage of biodiesel and its blends is the renewable, biodegradable, and environmental advantages. Biodiesel is made from methyl ester of fatty acid (FAME) and may be made in a variety of processes, including transesterification, pyrolysis, blending, and micro-emulsions. Transesterification, also known as alcoholyis, is a more prevalent reaction that occurs in the presence of a catalyst between vegetable oil (or animal fat) and an alcohol, primarily methanol or ethanol.

Jatropha Curcas belongs to euphorbiaceous family many years ago used for medicine treatment. It is non-edible feed stock having high oil content up to 40% and can grows everywhere like as sand, gravelly or saline soil. The production of seed can be achieved in 12 to 15 months after cultivation 2 or 3 times in a year. Now a days many researchers are working to produce biodiesel from jatropa seed to overcome on energy crisis for economical way. Therefore, it is expected in next few years 1 to 2 million hectors of jatropha crop will grow in the world.

The primary catalysts utilized can be characterized as homogeneous or heterogeneous based on their chemical presence in the transesterification process [4]. Homogeneous catalysts operate in the same liquid phase as the reaction mixture, whereas heterogeneous catalysts operate in a separate phase, generally as a solid from the reaction mixture [4]. Heterogeneous catalysts are noncorrosive, ecologically beneficial, and a green process. They may be recycled and reused several times, providing a more cost-effective method to biodiesel manufacturing. Biodiesel is the primary reaction product, with glycerol as a byproduct. Aside from its substantial advantages,
biodiesel may be a key energy source for diesel machines and, when compared to fossil fuels, burning it in engines emits less gas comprising hydrocarbons, polycyclic aromatic hydrocarbons, and NOx into the atmosphere. Glycerol is utilized in numerous personal care products as an emollient, humectant, solvent, and lubricant, including toothpaste, mouthwashes, shaving cream, and soaps. Nonetheless, biodiesel may encounter certain economic challenges. One of them is the high cost of feedstock, which makes it difficult to create biodiesel on a small scale. To eliminate this as a hurdle, this study aims to use Jatropha Curcas seed oil and CU doped Zinc Oxide nano catalyst for biodiesel production through transesterification.

Materials and Methodology:
Jatropha Curcas seed oil was obtained from the market. The moisture content was removed at 120°C for 1 hr. Prior to use, the samples were then stored in a desiccator to keep it free of moisture. Methanol, Copper and Zinc Oxide was purchased from Sigma-Aldrich Pakistan.

Methodology:

- **Catalyst Preparation:**
The catalyst was synthesized by Co-precipitation method. Zinc Oxide of 14.30g was added in 100 ml of distilled water was stirred with 500 rpm at room temperature for 2 hours. After that Copper sulphate of 0.64 g was added dropwise till 11 pH was reached to prepare CU doped Zinc Oxide nano catalyst. After that catalyst was dehydrated in an electric oven at 120°C for 12 hrs and calcinated at 800°C overnight with a gradual heating rate of 3°C/min. The dried catalyst was ground into powder form and kept into furnace for calcinations at 500°C for 2 hrs. Subsequently, prior to transesterification, the catalyst was activated at 450°C for 2 hours in the absence of oxygen [2].

- **Characterization of catalyst:**
  - **Atomic force microscopy (AFM):**
AFM studies were performed using Veeco AFM (model Nano Scope IIIa) along with a commercial AFM cell for liquids, adapted to include the corresponding electrodes, and integrated to an automated syringe (APEMA, model PU11U), working in once-through flux mode, for electrolyte delivery to the cell.
2.2.2. X-ray diffraction analysis:
The X-ray diffraction (XRD) technique was used to identify phase in a crystalline material and unit cell dimensions. For each analysis, the materials were finely powdered and placed snugly in the sample container. The XRD pattern of catalyst was scanned at 25°C using the Rigaku Miniflex diffractometer and Cu Ka (A= 1.54 A0) radiation. The X-ray tube voltage and current were set at 45 kV and 40 mA, respectively. Furthermore, each scan was performed throughout a range of 28 and 5° to 80° for each step size of 0.026° at a scanning rate of 0.05°/s [4].

FTIR analysis:
Fourier transform infrared (FTIR) spectroscopy was used to identify acid sites in catalyst samples. Using a Perkin-Elmer Spectrum 400 spectrophotometer, the spectra were recorded from 4000 to 400 cm⁻¹, with 45 scans at a resolution of 4 cm⁻¹ and measurements were used to investigate the Bronsted and Lewis acid sites of catalyst samples.

Scanning electron microscopy (SEM):
Scanning electron microscopy (SEM) studies was made via SEM, Leica Stereoscan 440 model manufactured by M/s. Leica Cambridge Ltd., UK. The powdered samples were mounted on the standard specimen stubs with the help of double adhesive tape and silver paste. The samples were glazed with a slim film of gold in Polaran coating unit E-5000 to avoid the charging of the sample. The electron beam parameters were set constant throughout the analysis of the loaded sample. The micro-graph of the samples with 10 kV EHT and 25 pA beam current were noted by a 35 mm camera attached on the high-resolution recording unit.

- Experimental setup and Transesterification:
Transesterification reaction was performed in 200 mL conical flask mounted on hotplate with temperature, speed and reaction time controller. Reactions were conducted under various Methanol to oil molar ratio (4:1–18:1), reaction temperature (110–160°C), reaction time (30–240 min), and catalyst loading amount (1–10 wt.%, based on the oil weight). In a typical batch run, 100 mL of Jatropha oil, 17 mL of Methanol, and 0.5 g of the catalyst was placed inside the conical flask. The reaction was performed at 70°C for 120 min with stirring rate of 500 rpm. The reaction resulted two visible layers one represents bio-diesel while the other shows glycerin formation. After the transesterification reaction, the catalyst was separated from the product through centrifugation.
Results and discussion:

Figure 1. shows the analogous atomic force microscopy to find out the size of particles with their range. In samples the size of particles from 0.5 to 52 nm with different percentage were observed whereas. Figure. 2 SEM shows the surface morphology, topography, composition, crystallographic and structural shape of synthesized Cu-ZnO nano catalyst. Figure 3. (a) XRD and (b) EDX of copper dopped ZnO catalyst. The results of this analysis depicted good morphology of prepared catalyst. XRD and EDX also displays the pattern of a model Cu-ZnO. The peaks in the XRD patterns of the generated samples are noticeably more comprehensive were Platy and granular than those in the patterns, which is the most prominent feature. In Figure. 5 (a) FTIR results showed the major functional groups identified were alkanes (2928-3000 cm\(^{-1}\), 1436 cm\(^{-1}\), 722 cm\(^{-1}\)), ketones (1714 cm\(^{-1}\)), aromatics (1436 cm\(^{-1}\)) and carboxylic acids (939 cm\(^{-1}\)). Among these functional groups, alkanes were qualitatively noted to be the main constituents which indicate the good catalytic cracking activity of the catalyst. However, catalyst also showed the least alkanes selectivity due to the absence of metal in the catalyst intrinsic framework. Another reason behind the less alkanes selectivity is the lack of Lewis acidic or basic sites of a structural element of CU restrained in the pores. Figure 5. (b) shows the UV, absorbance peak at 351 nm indicates the presence of ZnO nanoparticles, which is in accordance of UV absorbance result shown by previous studies, Akl M. Awwad et al., 2014 obtained peak at 377nm and Sivakumar et al., 2014 work has shown absorption peak at 325 nm for Zinc oxide nanoparticles.

Figure 5. shows the effect of temperature on biodiesel yield using copper dopped ZnO after transesterification. Results depicted that as the temperature is gradually increased from 25 to 45°C the conversion of triglycerides to bio-diesel was increase from 64.33 to 80 ml of ethanol concentration at 45°C. On further rise in temperature resulted 92% product yield. Furthermore, Figure 6. Shows the effect of methanol on bio-diesel yield. Results showed that as the methanol ratio subsequently increased from 1: 05 to 1: 12 which good indication of higher product yield.
Fig. 1: Atomic force microscopy of

Fig. 2: SEM copper dopped ZnO catalyst.

Fig. 3: (a) XRD and (b) EDX of copper dopped ZnO catalyst.

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Fig. 4: (a) FTIR and (b) UV-Vis of Diesel oil.

Fig. 5: Effect of Temperature on Biodiesel yield using copper dopped ZnO.
Conclusion:

Heterogenous copper based nano catalyst was synthesized by Co-precipitation method for the production of biodiesel. The Cupper dopped zinc oxide the nano particle size was used from 0.5 to 52 nm, and Transesterification method was used to produce the biodiesel. The optimum yield of bio-biodiesel was obtained 92% from Jatropha Curcas seed oil. SEM shows the surface morphology, topography, composition, crystallographic and structural shape of synthesized Cu-ZnO nano catalyst. XRD and EDX results depicted good morphology of prepared catalyst. XRD and EDX also displays the pattern of a model Cu-ZnO. FTIR results showed the major functional groups identified were alkanes (2928-3000 cm\(^{-1}\), 1436 cm\(^{-1}\), 722 cm\(^{-1}\)), ketones (1714 cm\(^{-1}\)), aromatics (1436 cm\(^{-1}\)) and carboxylic acids (939 cm\(^{-1}\)). Among these functional groups, alkanes were qualitatively noted to be the main constituents which indicate the good catalytic cracking activity of the catalyst. The UV, absorbance peak at 351 nm indicates the presence of ZnO nanoparticles, which is in accordance of UV absorbance result shown by previous studies. The effect of temperature on biodiesel yield using copper dopped ZnO depicted that as the temperature is gradually increased from 25 to 45°C the conversion of triglycerides to bio-diesel was increase from 64.33 to 80 ml of ethanol concentration at 45oC. On further rise in temperature resulted 92% product yield. Furthermore, Figure 8. Shows the effect of methanol on bio-diesel yield. Results showed that as the methanol ratio subsequently increased from 1:05 to 1:12 which good indication of higher product yield.
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References


Saima Noreen, Kalsoom Khalid, Munawar Iqbal, Hanadi. Baghdadi, Numrah Nisar, Umme Habibah Siddiqua f, Jan Nisar g, Yassine Slimani h, Muhammad I. Khan, Arif Nazir. (2021), Eco-benign approach to produce biodiesel from neem oil using heterogeneous nano-catalysts and process optimization., Environmental Technology & Innovation 22 (2021).


“The Production of Biodiesel Is Sustainable and Profitable Energy Source for Pakistan”. Pollster
j. acad.res. 05 (01) 32-38, 2018

Baskar Gurunathan, Aiswarya Ravi. ”process optimization and kinetics of biodiesel production
from neem oil using copper doped zinc oxide heterogeneous nanocatalyst”